

Flora of Brazilian humid Chaco: Composition and reproductive phenology

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ABSTRACT: We present the floristic composition and reproductive phenological data for a remnant of Arborized Stepic Savanna, vegetation type of humid Chaco, Porto Murtinho, Mato Grosso do Sul State, Brazil. We recorded 87 species of 31 families; Leguminosae presented the highest richness (14 species), followed by Malvaceae (9), Cactaceae (7) and Asteraceae (7). The herbaceous layer is relevant in the seasonal studied community (53.5% of the species) and there is predominance of non-perennial species (hemicryptophytes and therophytes), which demonstrate the importance of underground structures or seed banks in the vegetation. The community has continual flowering and fruiting with highest intensity in the rainy season, the most favorable period for plant growth and reproduction. The predominance of autochoric species in relation to anemochoric and zoochoric ones suggests partial independence of seed/fruit dispersal agents. Zoochorous species predominated in the rainy season, whereas anemochorous and autochorous species were more representative in the dry season.

INTRODUCTION

Chaco or “Gran Chaco” is the term applied to seasonal vegetation that covers the vast plains of north-central Argentina, south-eastern Bolivia, western Paraguay and Brazil, totaling about 800.000 km² (Prado 1993). In general the Chaco is divided into an eastern sector, with a more humid climate, and a western, drier sector, whilst the submeridional lowlands include a large depression between these two areas (Bianchi and Gibbs 2000). Chaquean vegetation is mainly formed by shrubs, spiny, deciduous and microphyllous, usually associated with saline soils (Silva *et al.* 2000). In Brazil, Chaco vegetation is restricted to the western border of Mato Grosso do Sul State, in Porto Murtinho (Silva and Abdon 1998; Pennington *et al.* 2000).

Despite occupying immense territorial area, there are relatively very few studies that recorded floristic and phenological data for the Chaco vegetation. In Argentina there is information on the herbaceous and woody flora from central Chaco (Zak and Cabido 2002; Cagnolo *et al.* 2006) and south regions (Marino and Pensiero 2003). In Brazil there is a floristic survey for one community (Nunes 2006) and only one study reporting tree species (Noguchi *et al.* 2009) in the most common forest types at Brazilian Chaco vegetations. Flowering phenodynamics is available for wild cucurbit (*Cucurbita maxima* ssp. *ondreono*) (Ashworth and Galetto 2001) and 43 Asteraceae species co-occurring in natural populations in central Argentina (Torres and Galetto 2011). Reproductive phenology of eight species with zoochorous diaspores was studied by Marco and Páez (2002) in central Argentina, and Noguchi *et al.* (2009) investigated fruit type and dispersal syndromes of tree species in some Brazilian Chaco vegetations.

We present a checklist of the flowering plants recorded

in a remnant of Arborized Stepic Savanna, a vegetation type of humid Brazilian Chaco. Additionally we characterize the habit, life form and dispersal syndrome of the ascertained species and present some reproductive phenological data for the community and the species.

MATERIALS AND METHODS

Data collection was made monthly in a remnant of humid Chaco (Arborized Stepic Savanna), in the Pantanal, sub-region of Porto Murtinho (Silva and Abdon 1998), Porto Murtinho municipality, Mato Grosso do Sul State (MS) (21°42'04"S, 57°53'06"W), from August 2010 to September 2011 (Figure 1). The Chaco climate is marked by strong seasonality, with hot summer with maximum temperature reaching 49° C, and dry and cold winter, with occasional frost. During the rainy season, temporary flooding may occur due to the poor drainage of the compact soil (Pennington *et al.* 2000). In the study area, rainy season occurs from November to February (rainfall ≥ 100mm) and dry season starts in April, becoming more pronounced from June to September, when water deficit occurs. Transition season occurs in March-May (from rainy to dry) and October (from dry to rainy), when there is no recorded water deficit, and rainfall reaches over 100 mm (Figure 2).

The floristic and phenological surveys were performed along five fixed transects, each about 200m long. All plants in reproductive phase within three meters of each side of the transect line were sampled. Samples of plant species were collected, identified and deposited in the CGMS Herbarium of Universidade Federal de Mato Grosso do Sul (UFMS). The identification of the plant species was made through comparison with specimens from CGMS Herbarium and with the support of specialists/

taxonomists. Families follow Angiosperm Phylogeny Group (APG III 2009). For the phenological studies, plants were evaluated considering presence or absence of buds, flowers (flowering) and fruits (immature, mature or fruiting). Classification of habits and life forms of plant species was made according to Guedes-Bruni *et al.* (2002) and Raunkiaer (1934 *apud* Radford *et al.* 1974), respectively. Dispersal syndromes were categorized according to Pijl (1982). Duration of flowering and fruiting phenology was classified according to Newstrom *et al.* (1994) in brief (< 1 month), intermediate (>1 month and <5 month) or extended (>5 month).

RESULTS AND DISCUSSION

We recorded 87 species belonging to 31 families. Leguminosae presented the highest richness (14 species), followed by Malvaceae (9), Cactaceae (7) Asteraceae and

Bromeliaceae (6 spp. each); the other families contributed with one to five species (Table 1). Leguminosae is one of the most representative families of the flora of Mato Grosso do Sul (Dubs 1998) and also presents high richness in different vegetation formations, including the Chaco (Alves and Sartori 2009; Noguchi *et al.* 2009).

Herbaceous species predominated (53.5% of the species) in relation to subshrubs (21.0%), trees (16.3%), epiphytes (5.8%) and lianas (3.4%). The herbaceous layer is able to recycle critical nutrients, dislocating them from underground organs (Monasterio and Sarmiento 1976). This fact associated with high efficiency in water use and high temperature optimizes photosynthesis, resulting in competitive success (Monasterio and Sarmiento 1976). Together, hemicryptophytes and therophytes (31.4% each) accounted for more than half of the studied species in the community, followed by chamaephytes (16.3%),

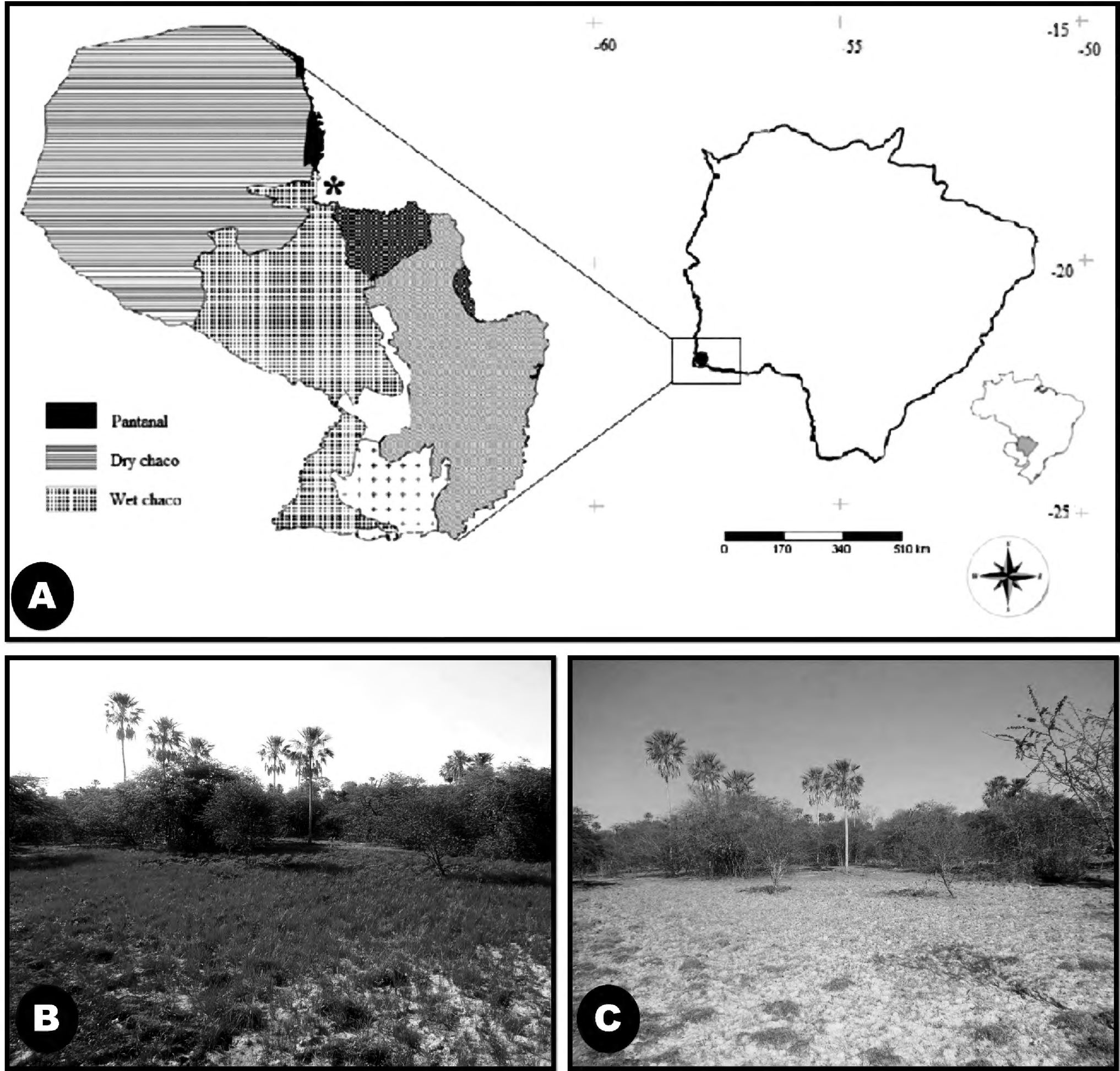


FIGURE 1. Major ecoregions of Paraguay neighboring Brazil and the municipality of Porto Murtinho, greatly associated with Wet Chaco, a Chaco biome (modified from Souza et al. 2010), *Municipality of Porto Murtinho, Mato Grosso do Sul State, Brazil (A). View of vegetation in wet (B) and dry (C) seasons in a remnant of Arborized Stepic Savanna, a vegetation type of humid Chaco of Brazil.

phanerophytes (15.1%) and geophytes (5.8%) (Table 1). The predominance of hemicryptophytes, therophytes and geophytes demonstrates the importance of underground structures or seed banks in the community as a strategy for maintenance of species in the environment during periods of water stress (Rebellato and Cunha 2005).

The studied community presented species blooming and fructifying during the whole study period (Figure 3A) and therefore the pattern of flowering and fruiting of the community is continual (*sensu* Newstrom *et al.* 1994). This fact is also observed in several studies in Cerrado vegetation (e.g. Batalha and Mantovani 2000; Batalha and Martins 2004; Munhoz and Felfili 2007).

Almost half the community presented flowering with intermediate duration (49.3%) followed by brief (37.4%) and extended (13.3%). Predominance of intermediate flowering is recorded in seasonal vegetations such as “cerrado” (Batalha *et al.* 1997) and mountain savanna (“campo rupestre”) (Dutra *et al.* 2009). Flowering was most intense in the rainy season, with marked reduction in the dry season (figure 3A), a pattern that was also observed in other seasonal vegetations such as Cerrado physiognomies (e.g. Batalha *et al.* 1997; Mantovani and Martins 1988; Munhoz and Felfili 2005). In the rainy season, the environmental conditions were more favorable, especially to herbaceous species, which predominate in this study. In environments marked by seasonality, water is available mainly in deep soil layers (Franco 2002), and herbaceous plants which have shallow roots (Ogle and Reynolds 2004) concentrate reproduction in the rainy season, while woody species, mainly trees, may reproduce even during the dry season (Monasterio and Sarmiento 1976; Batalha *et al.* 1997; Munhoz and Felfili 2005, 2007; Tannus *et al.* 2006).

Brief fructification (45.8%) predominated in the studied community, followed by intermediate (32.2%) and extended (22.0%) fructification (Table 1). Predominance of brief and intermediate fructification can be associated with short rainy season in the studied region (four months), and along with the high number of herbaceous species observed, the fructification of species is concentrated in moist periods (Castillo and Carabias 1982). It also demonstrates the importance of vegetative propagation for herbaceous species, which occupy the place due to their underground reserves (Mantovani and Martins 1988; Batalha and Mantovani 2000). In herbaceous and woody species, during the driest months, the highest proportion of anemochoric and autochory fructification is observed compared to zoochory (Mantovani and Martins 1988; Batalha *et al.* 1997). These fruits are generally dry and dehydrated to release their seeds (Batalha and Mantovani 2000). Under seasonal climate, anemochory is more efficient in the dry season (Augspurger and Franson 1987).

Highest intensity of fructification occurred during the whole rainy season and also in part of the transition season (from rainy to dry) (figure 3A). In seasonal environments, species tend to synchronize fruiting and dispersal with the onset of the rainy season to maximize seedling development and establishment, and species that disperse fruit in the dry season tend to have seed dormancy (Oliveira 1998; Felfili *et al.* 1999).

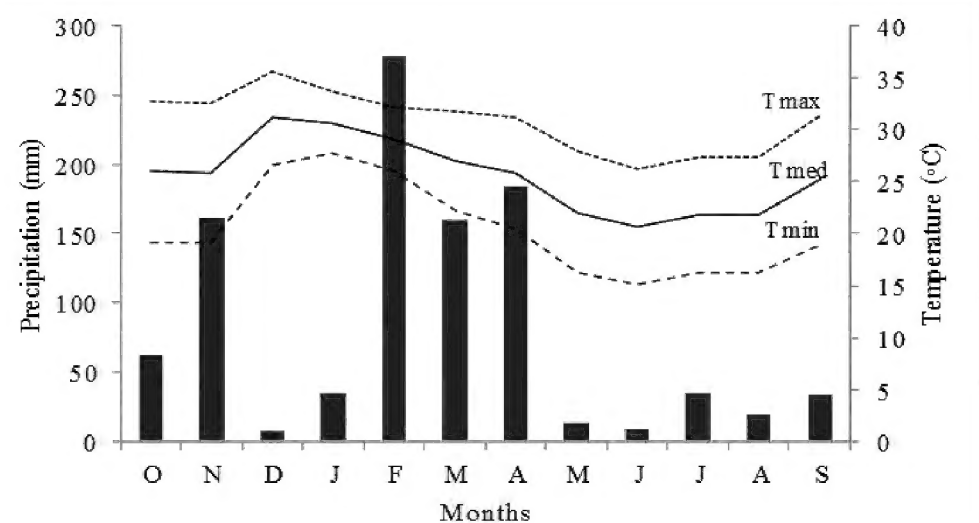
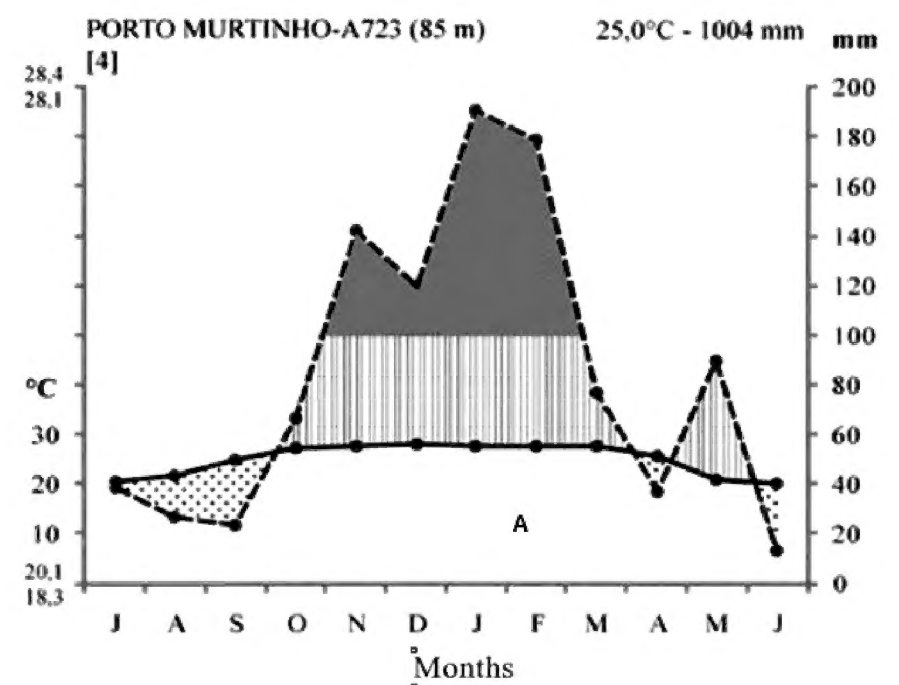


FIGURE 2. Climate diagrams of Porto Murtinho region, Mato Grosso do Sul State (MS): (A) climate diagram (Walter 1986) of Porto Murtinho, from 2006 to 2010; (B) distribution of accumulated precipitation (bars) and mean temperature (lines) during the study period (October/2010 to September/2011). Tmax = mean of maximum temperature; Tmed = average temperature; Tmin = mean of minimum temperature. Source: Centro de Monitoramento do Tempo, Clima e Recursos Hídricos de MS (CEMTEC).

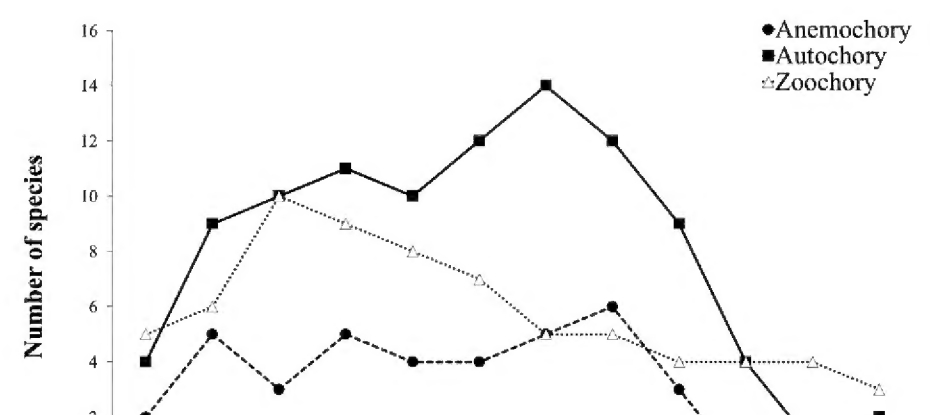
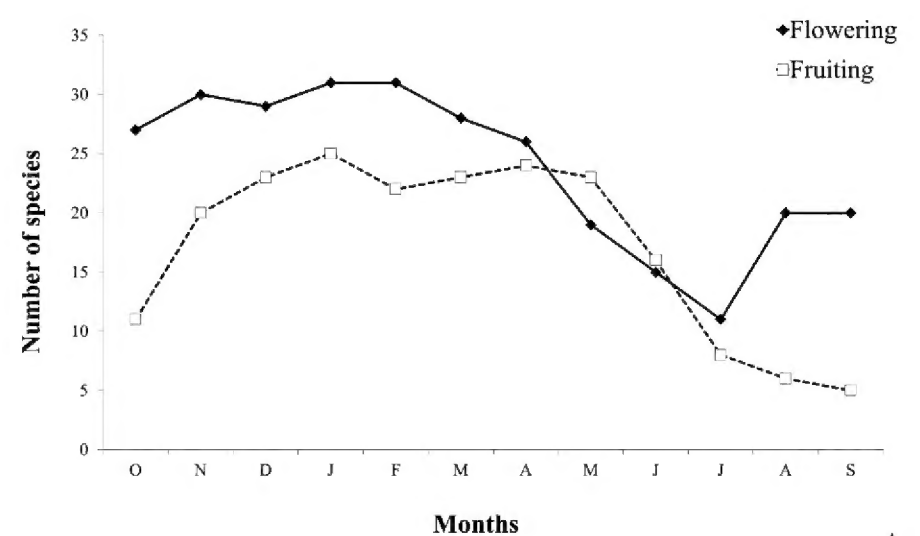


FIGURE 3. Richness of flowering and fruiting species (A) and distribution of three types of seed dispersal syndromes (B) in a remnant of Arborized Stepic Savanna, a vegetation type of humid Chaco, Mato Grosso do Sul State, Brazil, from October/2010 to September/2011.

Autochory predominated (65.5%) in relation to anemochory and zoochory (17.25% each) (Table 1) similar to the dispersal observed in other open vegetation formations (Oliveira and Moreira 1992; Vieira *et al.* 2002). All these types of dispersal syndromes were recorded during the whole study period (except anemochory in July) (Figure 3B). Zoochorous species had a better representation in the rainy season (mainly December), whereas anemochorous and autochorous species predominated during transitional and dry season, mainly May and April, respectively (figure 3B). Autochoric and anemocoric fruits tend to be produced generally in the driest periods when dispersion could be more efficient (Oliveira and Moreira 1992; Morellato and Leitão-Filho

1996; Batalha and Martins 2004). Dry fruits may be favored by Chaco physiognomy that consists mostly of Arborized Stepic Savanna, which is an open area (Noguchi *et al.* 2009).
Herbaceous layer is important in the seasonal studied community and there is predominance of short-perennial and annual species (e.g. hemicryptophytes, therophytes, geophytes) which demonstrate the importance of underground structures or seed banks for the community. The studied community has continual flowering and fruiting, but with highest intensity in the rainy season, the most favorable period for plant growth and reproduction. The predominance of autochoric species suggests partial independence on seed/fruit dispersal agents.

TABLE 1. Habit, life form and characteristics of flowering and fruiting phenology of the plant species sampled in a remnant of humid Chaco (Arborized Stepic Savanna), Porto Murtinho municipality, Mato Grosso do Sul State, Brazil, from August 2010 to June 2011. Habit: A = arboreal, H = herbaceous, L = liana, S= subshrubby, E= epiphyte; Life forms: Ch = chamaephyte, Ph= phanerophyte, Ge = geophyte, He = hemicryptophyte, Te = therophyte; Duration: Inter = intermediate; Dispersal syndrome = ANEMO = anemochory; AUTO = autochory, ZOO = zoochory; ind. = indetermined.; CGMS = Herbarium CGMS; n° = number.

SPECIES	Habit	Life form	FLOWERING			FRUTIFICATION			CGMS	
			Season		Duration	Season		Duration	Dispersal	record
			Dry	Wet	(n° months)	Dry	Wet	(n° months)	syndrome	n°
Acanthaceae										
<i>Justicia clivalis</i> Wassh.	H	Te	X		brief (1)	ind.	ind.	brief (1)	AUTO	35255
<i>Justicia laevilinguis</i> (Nees) Lindau	H	Te	X		inter (2)	ind.	ind.	inter (2)	AUTO	35447
<i>Ruellia tweediana</i> Griseb.	H	He		X	brief (1)	ind.	ind.	brief (1)	AUTO	35277
Apocynaceae										
<i>Rhabdadenia pohlii</i> Müll. Arg.	H	Te		X	brief (1)	X	X	ind.	AUTO	36891
Asclepiadaceae										
Asclepiadaceae 1	A	Te	X		brief (1)	X		ind.	AUTO	35473
Amaranthaceae										
<i>Alternanthera</i> sp.	H	He	X	X	inter (5)	X		extended (8)	ANEMO	35444
<i>Froelichia procera</i> (Seub. and Mart.) Pedersen	H	He	X		inter (3)	X		inter (3)	AUTO	35263
<i>Gomphrena celosioides</i> Mart.	H	Te	X		brief (1)	X	X	brief (1)	AUTO	35445
<i>Gomphrena elegans</i> Mart.	H	Te		X	brief (1)	X		brief (1)	AUTO	35419
<i>Pfaffia glomerata</i> (Spreng.) Pedersen	H	He	X	X	inter (4)	ind.	ind.	inter (3)	AUTO	35224
Anacardiaceae										
<i>Astronium</i> sp.	A	Ph	X		inter (2)	X		inter (4)	ZOO	36878
Asteraceae										
<i>Eupatorium</i> sp.	H	Te	X		brief (1)	X	X	ind.	AUTO	35436
<i>Pectis gardneri</i> Baker	H	Te		X	brief (1)	X	X	inter (7)	ANEMO	35462
<i>Lepidaploa muricata</i> (DC.) H.Rob.	H	Te	X	X	extended (11)	ind.	ind.	extended (8)	ANEMO	35265
<i>Soliva</i> sp.	H	Te	X		brief (1)	ind.	ind.	brief (1)	ANEMO	36889
<i>Sphagneticola trilobata</i> (L.) Pruski.	H	Te	X	X	inter (3)			brief (1)	ANEMO	35449
<i>Vernonia</i> sp.	H	Te	X	X	extended (11)	ind.	ind.	extended (8)	ANEMO	35446
Bignoniaceae										
<i>Tabebuia nodosa</i> (Griseb.) Griseb.	A	Ph	X	X	inter (4)		X	inter(2)	ANEMO	37104
Boraginaceae										
<i>Cordia glabrata</i> (Mart.) A.DC.	A	Ph	X	X	inter (2)		X	brief (1)	ANEMO	36879
Bromeliaceae										
<i>Bromelia balansae</i> Mez	S	He		X	inter (3)		X	extended (12)	ZOO	37106
<i>Bromelia hieronymi</i> Mez	S	He		X	inter (2)		X	extended (12)	ZOO	36880
<i>Tillandsia didisticha</i> (E.Morren) Baker	E	He	X		inter (4)	ind.	ind.	ind.	ANEMO	36893
<i>Tillandsia duratii</i> Vis.	E	He		X	ind.	ind.	ind.	ind.	ANEMO	36881
<i>Tillandsia loliacea</i> Mart. ex Schult. f.	E	He		X	ind.	ind.	ind.	ind.	ANEMO	36882
<i>Tillandsia recurvifolia</i> Hook.	E	He		X	ind.	ind.	ind.	ind.	ANEMO	36883
Cactaceae										
<i>Cereus bicolor</i> Rizzini e Mattos	A	Ph		X	inter (3)		X	inter (3)	ZOO	
<i>Cleistocactus</i> cf. <i>baumannii</i> (Lem.) Lem.	S	He		X	inter (2)		X	brief (1)	ZOO	35477
<i>Echnopsis rhodotricha</i> K. Schum.	S	Ch		X	inter (2)		X	brief (1)	ZOO	36887
<i>Harrisia balansae</i> (K. Schum.) N.P. Taylor and Zappi	S	Ph	X	X	inter (6)		X	inter (4)	ZOO	35455
<i>Opuntia bergeriana</i> F.A.C. Weber	S	He		X	inter (2)		X	brief (1)	ZOO	35475

TABLE 1. CONTINUED.

SPECIES	Habit	Life form	FLOWERING			FRUITIFICATION			CGMS	
			Season		Duration	Season		Duration	Dispersal	record
			Dry	Wet	(n° months)	Dry	Wet	(n° months)	syndrome	n°
<i>Pereskia sacharosa</i> Griseb.	S	Ph		X	inter (4)		X	inter (5)	ZOO	35454
<i>Rhipsalis</i> cf. <i>baccifera</i> (J.S. Muell.) Stearn	E	Te	X	X	inter (3)	X	X	extended (9)	ZOO	36886
Capparaceae										
<i>Capparis retusa</i> Griseb.	A	Ph		X	inter (2)		X	inter (2)	ZOO	35453
Cleomaceae										
<i>Cleome guianensis</i> Aubl.	H	Te	X	X	inter (4)		X	brief (1)	AUTO	35426
Commelinaceae										
<i>Commelina nudiflora</i> L.	H	He		X	brief (1)	X		brief (1)	AUTO	35262
<i>Tradescantia</i> sp.	H	He		X	inter (2)	ind.	ind.	ind.	AUTO	35483
<i>Tripogandra glandulosa</i> (Seub.) Rohw.	H	He		X	inter (4)		X	inter (6)	AUTO	35478
Convolvulaceae										
<i>Evolvulus sericeus</i> Sw.	H	Te	X	X	inter (2)			extended (6)	AUTO	35442
<i>Ipomoea</i> sp.	L	Te	X		brief (1)	ind.	ind.	ind.	AUTO	35470
Euphorbiaceae										
<i>Cnidoscolus urens</i> (L.) Arthur	S	Ch	X		inter (4)	ind.	ind.	ind.	AUTO	35476
<i>Croton</i> sp. 1	S	Ch		X	inter (2)	ind.	ind.	ind.	AUTO	35441
<i>Croton</i> sp. 2	S	Ch		X	brief (1)	ind.	ind.	ind.	AUTO	35443
<i>Euphorbia hyssopifolia</i> L.	H	Te	X	X	brief (1)	X	X	extended (7)	AUTO	37101
<i>Jatropha</i> sp.	S	He	X	X	extended (12)	ind.	ind.	ind.	AUTO	35479
Lamiaceae										
<i>Hyptis brevipes</i> Poit.	H	Te	X		brief (1)	X		brief (1)	AUTO	37107
Leguminosae										
<i>Aeschynomene mollicula</i> Kunth.	H	He		X	brief (1)	ind.	ind.	ind.	AUTO	35430
<i>Arachis microsperma</i> Krapov., W.C. Greg. and Valls	H	He	X	X	inter (3)	X	X	brief (1)	AUTO	35434
<i>Chamaecrista serpens</i> (L.) Greene	H	He	X	X	inter (2)	ind.	ind.	ind.	AUTO	35422
<i>Galactia latisiliqua</i> Desv.	H	He	X	X	inter (3)		X	brief (1)	AUTO	35427
<i>Galactia paraguariensis</i> Chodat and Hassl.	S	Te		X	inter (4)	X	X	extended (7)	AUTO	35428
<i>Mimosa sensibilis</i> Benth.	A	He	X	X	extended (4)	ind.	ind.	ind.	AUTO	35464
<i>Mimosa</i> sp.	S	He	X		brief (1)	ind.	ind.	ind.	AUTO	35433
<i>Neptunia pubescens</i> Benth.	S	Ge		X	inter (2)	ind.	ind.	ind.	AUTO	35466
<i>Parkinsonia praecox</i> (Ruiz and Pav. ex. Hook.) Hawkins	A	Ph	X		inter (2)	ind.	ind.	ind.	AUTO	35472
<i>Prosopis rubriflora</i> Hassl.	A	Ph	X	X	extended (12)	ind.	ind.	ind.	AUTO	35469
<i>Senegalia</i> sp.	A	Ph	X		brief (1)	ind.	ind.	ind.	AUTO	35467
<i>Senna pilifera</i> (Vog.) H.S. Irwin and Barneby	H	He	X		inter (3)		X	brief (1)	AUTO	35465
<i>Stylosanthes hamata</i> (L.) Taub.	H	He	X	X	extended (6)	X	X	brief (1)	AUTO	35458
<i>Zornia reticulata</i> Sm.	H	He		X	brief (1)		X	brief (1)	AUTO	35432
Lythraceae										
<i>Cuphea thymoides</i> Cham. and Schltdl.	H	Ch		X	inter (3)	ind.	ind.	ind.	AUTO	35438
Malpighiaceae										
<i>Heteropterys glabra</i> Hook. and Arn.	L	Te	X		brief (1)	X		brief (1)	ANEMO	35460
Malpighiaceae 1	L	Te	X	X	brief (1)	ind.	ind.	ind.	ANEMO	35481
Malvaceae										
<i>Ayenia tomentosa</i> L.	H	Ch	X		brief (1)	X		brief (1)	AUTO	35461
<i>Corchorus argutus</i> Kunth.	H	He	X		brief (1)	X		brief (1)	AUTO	36890
<i>Herissantia nemoralis</i> (A.St. Hil.) Briz.	H	Ch		X	brief (1)	ind.	ind.	ind.	AUTO	35420
<i>Melochia pyramidata</i> L.	H	He		X	inter (2)	ind.	ind.	ind.	AUTO	35448
<i>Pavonia sidifolia</i> Kunth	A	Ch	X	X	extended (7)		X	inter (4)	AUTO	35456
<i>Sida angustissima</i> A. St-Hilaire	H	Ch		X	brief (1)		X	breve (1)	AUTO	35273
<i>Sida cerradoensis</i> Krap.	S	Ch	X	X	inter (4)	X		inter (2)	AUTO	35425
<i>Sida rhombifolia</i> L.				X	brief (1)	ind.	ind.	ind.	AUTO	35468
<i>Waltheria indica</i> L.	S	Ch	X	X	inter (3)	X	X	brief (1)	AUTO	35423
Molluginaceae										
<i>Mollugo verticillata</i> L.	H	Te	X	X	extended (7)	X	X	extended (8)	ZOO	35421
Myrtaceae										
Myrtaceae 1	A	Ph	X		brief (1)	und.	und.	und.	ZOO	35471
Onagraceae										
<i>Ludwigia lagunae</i> (Morong) H. Hara	H	Te	X		brief (1)	X		brief (1)	ANEMO	37105

TABLE 1. CONTINUED.

SPECIES	Habit	Life form	FLOWERING			FRUITIFICATION			CGMS	
			Season		Duration	Season		Duration	Dispersal	record
			Dry	Wet	(n° months)	Dry	Wet	(n° months)	syndrome	n°
Oxalidaceae										
<i>Oxalis latifolia</i> Kunth.	H	Ge	X		inter (4)	X		inter (3)	AUTO	35269
<i>Oxalis physocalyx</i> Zucc. ex Progel	H	Te	X		brief (1)	X		inter (3)	AUTO	37108
Plantaginaceae										
<i>Monopera</i> sp.	H	Te		X	brief (1)		X	brief (1)	AUTO	35439
<i>Scoparia montevidensis</i> (Spreng.) R.E. Fr.	H	Te	X	X	extended (8)	X		extended (10)	AUTO	35418
Portulacaceae										
<i>Portulaca fluvialis</i> D. Legrand	H	Ge	X	X	extended (7)		X	inter (4)	AUTO	35451
<i>Portulaca striata</i> Poelln.	H	Ge	X	X	inter (5)	X	X	inter (4)	AUTO	35435
Rubiaceae										
<i>Spermacoce eryngioides</i> Cham. and Schltdl.	H	Ch	X	X	extended (10)	X	X	extended (8)	AUTO	35457
<i>Staelia thymoides</i> Cham. and Schltdl.	H	Te	X		inter (2)	X		brief (1)	AUTO	35429
Rhamnaceae										
<i>Ziziphus mistol</i> Griseb.	A	Ph	X	X	inter (5)	X	X	extended (8)	ZOO	35463
Simaroubaceae										
<i>Castela coccinea</i> Griseb.	A	Ph	X		inter (3)	X		inter (4)	ZOO	35480
Talinaceae										
<i>Talinum triangulare</i> (Jacq.) Willd	H	Ge	X		brief (1)	X		brief(1)	AUTO	35459
Verbenaceae										
<i>Lippia alba</i> (Mill.) Br. ex Britt.and Wilson	S	Ch	X		brief (1)	X		brief (1)	AUTO	37109
<i>Stachytarpheta elatior</i> Schr. ex Schult	S	Ch	X		brief (1)	X		inter (3)	AUTO	35474

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